Announcements

- Homework for tomorrow…

  Ch. 32: Probs. 38, 39, & 63

  CQ7: a) into page b) no deflection
  32.16: a) 3.1×10^{-4} Am^2 b) 5.0×10^{-7} T
  32.18: a) 6.2×10^{-5} T b) 1.8×10^{9} A
  32.48: 4.1×10^{-4} T, into the page

- Office hours…

  MW 10-11 am
  TR 9-10 am
  F 12-1 pm

- Tutorial Learning Center (TLC) hours:

  MTWR 8-6 pm
  F 8-11 am, 2-5 pm
  Su 1-5 pm

Chapter 32

The Magnetic Field

(*Magnetic Forces on Current-Carrying Wires & Forces and Torques on Current Loops*)

Review...

- The *radius* and *frequency* for cyclotron motion...

$$r_{cyc} = \frac{mv}{qB}$$

$$f_{cyc} = \frac{qB}{2\pi m}$$

- The *force* on a current-carrying wire in a *B*-field is...

$$\vec{F}_{wire} = I\vec{\ell} \times \vec{B}$$

Force Between Two Parallel Wires

What is the force on wire$_1$ due to wire$_2$?

$\alpha = 90°$

$F_{21}\,? = I_1 \ell B_2 \sin\alpha$

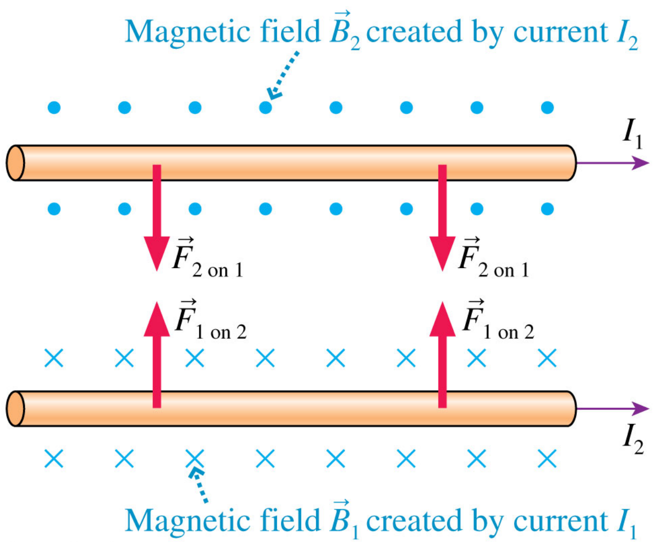
$\vec{B}_2 = \frac{\mu_0 I_2}{2\pi d}$

$= \frac{\mu_0 \ell I_1 I_2}{2\pi d}$

$F_{12}\,? = I_2 \ell B_1 \sin\alpha$

$\vec{B}_1 = \frac{\mu_0 I_1}{2\pi d}$

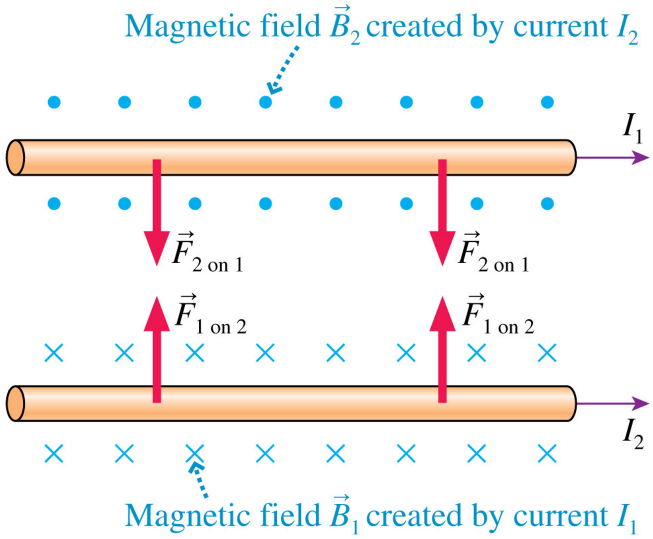
$= \frac{\mu_0 \ell I_1 I_2}{2\pi d}$



Force Between Two Parallel Wires

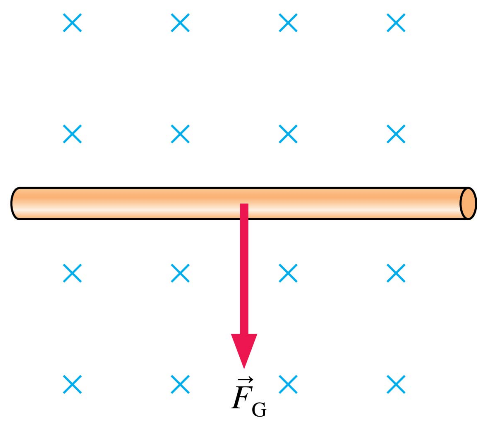
What is the force on $wire_1$ due to $wire_2$?

$$F_{1\ on\ 2} = F_{2\ on\ 1} = \frac{\mu_0 \ell I_1 I_2}{2\pi d}$$



Quiz Question 1

The horizontal wire can be levitated – held up against the force of gravity – if the current in the wire is

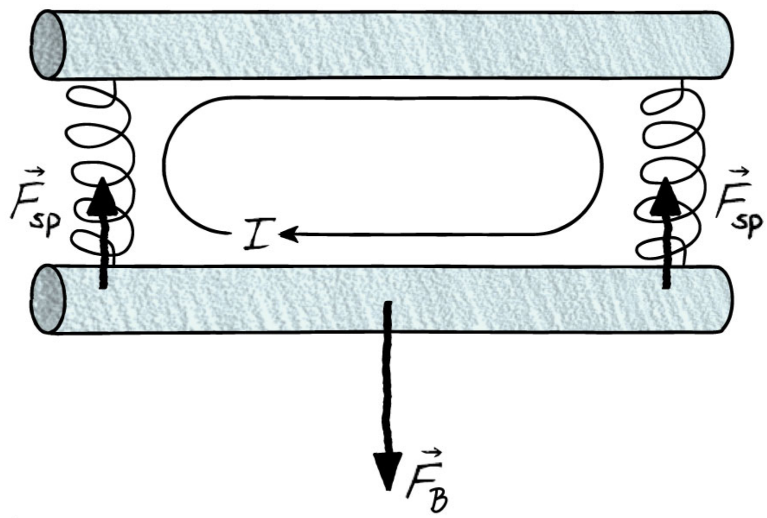


1. Right to left.
2. Left to right.
3. It can't be done with this magnetic field.

i.e. 32.14
A current balance

Two stiff, 50 cm long parallel wires are connected at the ends by metal springs. Each spring has an unstretched length of 5.0 cm and a spring constant of 0.025 N/m. The wires push each other apart when a current travels around the loop.

How much current is required to stretch the springs to lengths of 6.0 cm?



$\sum F_y = ma : \sum F_y = 0$

$\Delta y = 1.0 \times 10^{-2} m$

$l = 0.5 m$

$d = 6.0 \times 10^{-2} m$

$K = 0.025 \ N/m$

$2F_{sp} - F_B = 0$

$F_B = 2F_{sp}$

$F_B = 2K\Delta y$

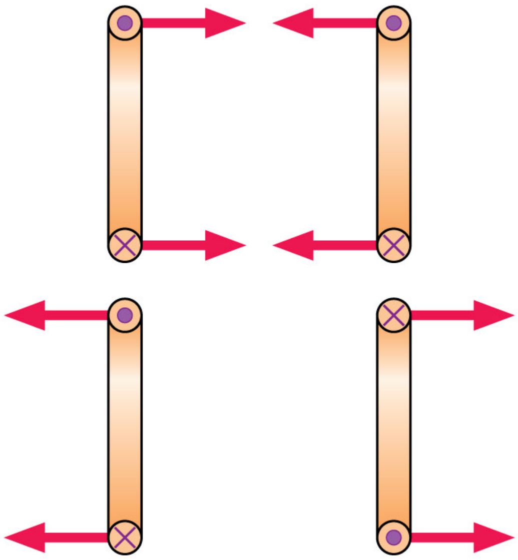
$\frac{\mu_0 l I^2}{2\pi d} = 2K\Delta y$

$I = \sqrt{\frac{4\pi d K \Delta y}{\mu_0 l}}$

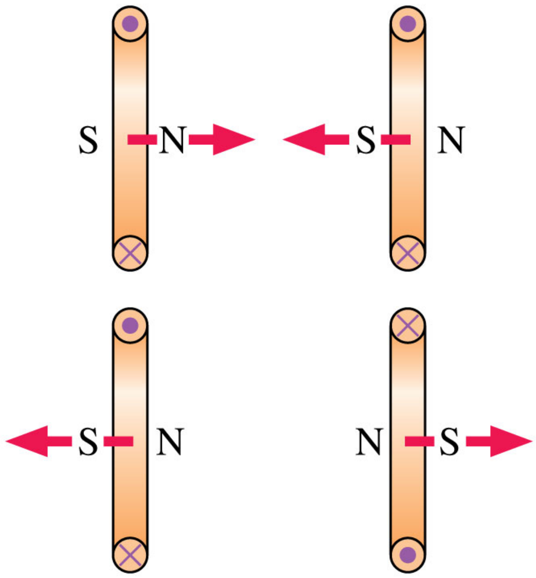
$I = 17A$

32.9
Forces and Torques on Current Loops

Alternative but equivalent ways to view magnetic forces between two current loops.



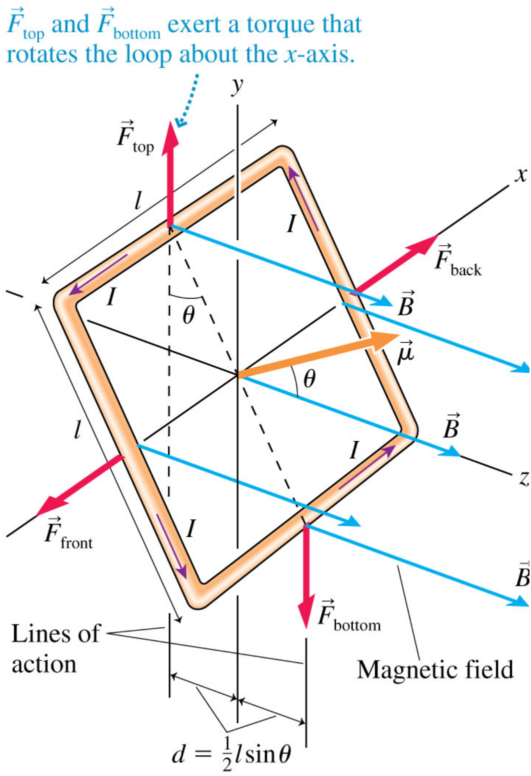
Parallel currents *attract*, *opposite* currents *repel*.



Opposite poles *attract*, *like* poles *repel*.

32.9 Forces and Torques on Current Loops

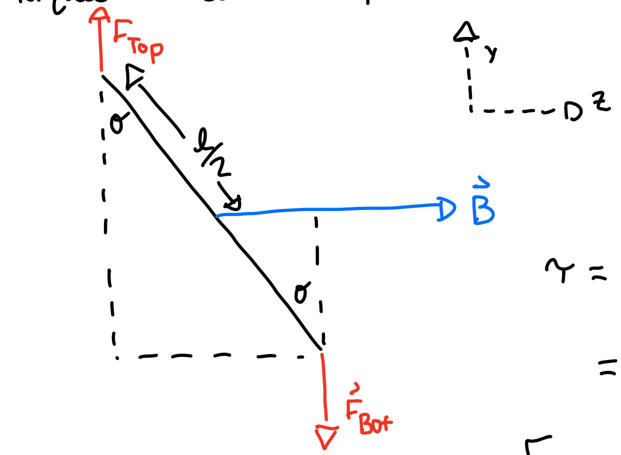
Consider a current loop in a *B*-field…



- F_{front} and F_{back} are *opposite* in direction, but *equal* in magnitude, therefore $\Sigma F_x = 0$.
- F_{top} and F_{bottom} are *opposite* in direction, but *equal* in magnitude, therefore $\Sigma F_y = 0$.
- F_{top} and F_{bottom} exert a *net torque*, therefore $\Sigma\tau \neq 0$!

So what is the *net torque*?

Torques on current loops



$$\tau = dF_{Top}\hat{\imath} + dF_{Bot}\hat{\imath}$$

$$= 2dF_{Top}\hat{\imath}$$

$$F_{Top} = IlB$$

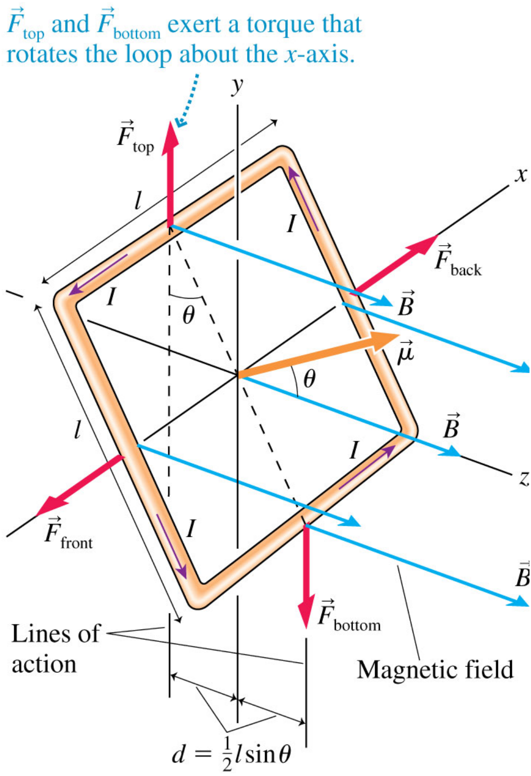
$$= 2\frac{l}{2}\sin\theta \cdot IlB\hat{\imath}$$

$$F_{Top} = Il^2B\sin\theta = \mu B\sin\theta\,\hat{\imath}$$

32.9 Forces and Torques on Current Loops

Consider a current loop in a B-field…

- F_{front} and F_{back} are *opposite* in direction, but *equal* in magnitude, therefore $\Sigma F_x = 0$.
- F_{top} and F_{bottom} are *opposite* in direction, but *equal* in magnitude, therefore $\Sigma F_y = 0$.
- F_{top} and F_{bottom} exert a *net torque*, therefore $\Sigma\tau \neq 0$!

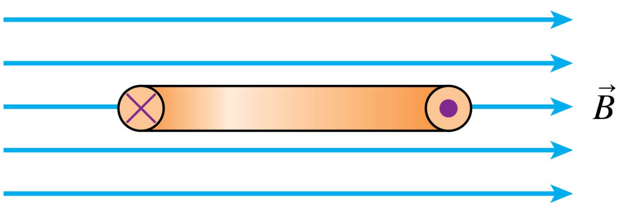


So what is the *net torque*?

$$\boxed{\vec{\tau} = \vec{\mu} \times \vec{B}}$$

Quiz Question 2

If released from rest, the current loop will



1. Move upward.
2. Move downward.
3. Rotate clockwise.
4. Rotate counterclockwise.
5. Do something not listed here.

32.9
Forces and Torques on Current Loops

A simple electric motor…